Report No. 27.

MEDICAL RESEARCH COUNCIL.

INDUSTRIAL FATIGUE RESEARCH BOARD.

Results of Investigation in certain Industries.

LONDON:

Published by His Majesty's Stationery Office, and to be purchased at any of the addresses shown on page 15.

1924.

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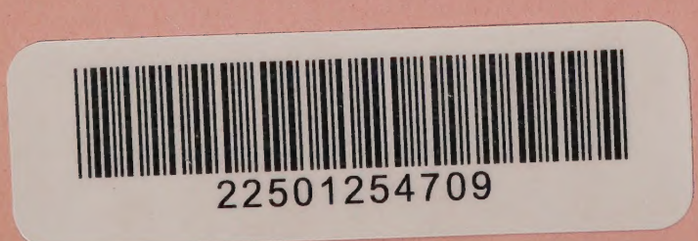

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TERMS OF REFERENCE.

To suggest problems for investigation, and to advise upon or carry out schemes of research referred to them from time to time by the Medical Research Council, undertaken to promote better knowledge of the relations of hours of labour and of other conditions of employment, including methods of work, to functions of the human body, having regard both to the preservation of health among the workers and to industrial efficiency; and to take steps to secure the co-operation of industries in the fullest practical application of the results of this research work to the needs of industry.

OFFICES:

15, York Buildings, Adelphi, London, W.C.2.

PREFACE.

The Industrial Fatigue Research Board, which works under the control of the Medical Research Council, was appointed in 1918 to carry out investigations with a view to finding the most favourable hours of work and other conditions of employment applicable to industrial occupations according to the nature of the work and its demands on the worker.

In this country the first recognition that the human factor in industry was deserving of scientific study occurred in 1893, when Sir William Mather conducted his well-known experiment at Messrs. Mather and Platt, of Manchester, of abolishing the pre-breakfast spell of work, and so reducing the weekly hours of work from 54 to 48. Two years' experience proved that the change had brought about a considerable increase in production and a decrease in the amount of lost time. On the basis of this experiment, the 48-hour week was introduced at the Government arsenals or dockyards, but on the other hand, the results obtained from Messrs. Mather and Platt's experiment, suggestive as they were, did not lead to any general adoption of analogous methods on the part of privately owned establishments.

The further development of knowledge on these questions depended for many years on research carried out in other countries, especially in America and Germany, where in the years before the war many organised studies in industrial physiology and psychology had been made, whilst in this country little progress was made apart from the formation by the British Association in 1913 of a research Committee for the purpose of investigating fatigue from the economic standpoint.

The experience of the war, with the demands it brought for strenuous and long-maintained industrial effort by the workers, brought home our national lack of knowledge of the primary laws governing human efficiency, and in particular the need for scientific study of the hours of work and other conditions of labour likely to produce the maximum output at which the effort of the whole people was aimed. In the absence of such knowledge, work was undoubtedly carried on in many cases under conditions as to hours which were not only progressively detrimental to the maintenance of output for long periods but also immediately detrimental even for short periods.

In 1915 the Health of Munition Workers Committee was formed to carry out research on these questions, and several

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reports were subsequently published. These pioneer investigations, which were necessarily limited to war conditions of industry and to the making of munitions, were productive of results sufficiently striking in themselves, but still more so in their potential application to industries generally. On the disbandment of this Committee in 1917, therefore, the Board was appointed by the Medical Research Council and the Department of Scientific and Industrial Research to continue the work on more comprehensive lines by embracing the whole of industry within its scope.

Clear indications now exist that interest in work of the kind carried out by the Board is rapidly growing. This is shown not only by the continually increasing number of requests for information and of suggestions for investigation received, but still more by the institution in this country of a self-supporting body, the National Institute of Industrial Psychology, founded in 1921, with interests and functions akin to those of the Board.

During the past six years knowledge has accumulated which the Board cannot but think is of great importance to all engaged in industry. Maximum output is contingent on maximum fitness of the individual worker, and this in turn can only be attained by providing the most healthy and comfortable conditions and methods of work.

The numerous investigations conducted by the Board during their existence fall into two main categories. Some have been inquiries of a wide character, not limited to any one industry, but extending to all. Of this type are the investigations into optimum length of spell, the personal factors in accident causation, and the physiology of ventilation. Others have consisted in the study of the conditions of certain industries, (selected partly on account of their importance and partly because they appeared to offer specially promising features for the study of industrial fatigue and efficiency), which have been explored, not in any one direction, but on general lines according to the facilities available.

In investigations of the latter class, work has been conducted mainly by physiological, psychological and statistical methods, and the final results have been submitted for scientific criticism to the appropriate Committees of the Board. At the same time, to ensure that the technical aspects should not be neglected, and that the recommendations put forward on the completion of the investigation should not be open to serious practical objection, the actual supervision has been in the hands of Committees containing representatives of the industry concerned.

The investigations conducted on these lines have almost always produced definite recommendations on the part of the investigators, either for the application to the industry concerned of

the results disclosed by the inquiry, or for the opening up of new fields of research. The weight behind these recommendations naturally varies with the circumstances. In some instances the conclusions on which they are based are admittedly tentative, and further exploration is required; in others, either because they confirm what would be expected on physiological or other scientific grounds, or because they have been arrived at independently in several different inquiries, they may be regarded as definitely established. The latter have usually led to concrete suggestions for some modifications or adjustment in existing industrial methods, and it is at this stage that the work of the Board, which aims primarily at the acquisition of knowledge, becomes ready to be translated by industries into practice.

The Board contemplate the preparation eventually of an analysis of the whole of the work carried out by them, in which the general conclusions reached in regard to such matters as ventilation, lighting, noise, etc. will be fully treated. In the meantime, in order to bring their results more prominently to the notice of industries they have decided to issue the present memorandum, limited to a brief summary of the principal recommendations in the published reports of the Board which already await application or further investigation on the part of certain industries.

In the opinion of the Board many of these recommendations are sufficiently authoritative to justify provisional adoption on a large scale with a great probability of success, though it is of course desirable that they should be first tested on a provisional basis and on a comparatively limited scale.

At this stage full weight must clearly be given to technical considerations, and the Board hope that industry itself may be disposed to take a full and even predominant part in the continuation of their work. On this point the Board, in their Fourth Annual Report, have suggested that in each important industry a small committee should be set up, representative of employers and workmen, who should be responsible for examining results submitted by the Board, and after criticism applying them in the way already described. In addition to this special work, the Committee could meet periodically to discuss problems affecting the human factor in industry, to consider proposals submitted by bodies such as the Board and the National Institute of Industrial Psychology, and to approve the initiation of new research.

In issuing this memorandum, the Board would add that most of the recommendations contained in it have been put forward with the concurrence of representatives of the industries concerned, and they hope therefore that these industries will give careful consideration to the question of giving them practical effect on the lines already described.

RESULTS OF INVESTIGATION IN CERTAIN INDUSTRIES.

CONTENTS.

Introduction.

This memorandum contains a complete summary of the recommendations relating to specific industries which have appeared in the published reports of the Industrial Fatigue Research Board. For full details the original reports must be consulted, and to admit of this being easily done, references have been inserted in the text, the serial number of the report being indicated by the thick figures and the appropriate page by the thin.

These recommendations are of different kinds. Some merely suggest promising new fields of research in which no work has yet been carried out; others advocate the adoption of certain practices with a view to the accumulation of data to be subsequently used for the acquisition of knowledge; others again deal with the actual applications to industry itself of the results already disclosed by the investigation.

In the present memorandum it has seemed better not to distinguish the recommendations in this sense, but to arrange them according to the industry and the class of subject to which they refer. They have accordingly been grouped first under the

industry (or class of industries) investigated (though results obtained in one industry may often have a direct bearing on others), and secondly under the following three headings :—

(*a*) Working conditions (including all questions concerning the workers as a whole).

(*b*) Working methods (including all questions concerning more especially the individual worker).

(*c*) Administrative and miscellaneous (including such matters as record keeping, etc.).

In commending these recommendations to the consideration of the industries concerned, the Board desire to offer the following observations :—

(1) The usual measure adopted in the investigations has been output, mainly because in our present state of knowledge output, when suitable precautions are taken, is probably the most reliable index of fitness on the part of the worker. At the same time it has the advantage of illustrating the fact, already alluded to in the preface, that the recommendations are of direct interest to all engaged in industry. If, for instance, proof can be adduced that the workers react to certain conditions in such a way that output is reduced, owing to causes that can probably be remedied, the employer and the workman have a common interest in bringing about the necessary improvement.

(2) The effects to which some of the recommendations refer are already well known to exist. In these instances the chief value of the investigation lies in determining more precisely the extent to which the various factors operate.

(3) The response to change of conditions as measured in the investigations varies greatly in its numerical value. Where it relates to the individual worker it is often very marked, but in such cases it is clearly inadmissible to conclude that this effect will be general. There are indications, indeed, that improvement in working methods has a much greater effect on the sub-average worker than on the initially efficient worker. Where, however, investigation has dealt with large groups of workers, the response, though less marked, is of much wider application.

(4) Since the earlier investigations were completed practical changes may in some instances have been introduced into the industries explored. The Board believe, however, that generally speaking the conditions, apart from alteration of hours of work due to industrial depression, have not usually been modified sufficiently to affect the applicability of the recommendations put forward.

I.—TEXTILE INDUSTRIES.

(*a*) Working Conditions.

1. *Humidity and Temperature.* (*Cotton and Fine Linen Weaving.*)—In some textile processes, particularly in cotton and fine linen-weaving, the atmospheric conditions, owing to the exigencies of manufacture, are necessarily not free from criticism on physiological grounds. The humidity introduced, together with the daily rise of temperature, combine to produce a wet-bulb temperature which often rises above the limit which is generally accepted as physiologically desirable for the kind of work carried on, and the same comment applies to the kata-thermometer records, which, so far as the Board's observations extend, compare unfavourably with those obtained in many other industries [**21,** 21].

It has been shown that a high temperature and a high degree of humidity have a beneficial physical effect on the yarn in weaving, and there is some evidence to show that productive efficiency varies as the product of the relative humidity and the temperature [**23,** 17]. In spite of this, it is found that production begins to fall when the wet-bulb reaches 72°–73° F., and this effect can only be due to an involuntary reduction in the working capacity of the operatives [**20,** 14 ; **23,** 41].

As a corollary to this, it follows that the industries concerned would be well advised to consider :—

(*a*) Whether means can be adopted for preventing the temperature from rising above the critical limit [**23,** 48] ;

(*b*) If this is impracticable, whether alleviation of the effects can be secured by the adoption of practicable methods, such as increasing the air movement by special devices or the wearing of clothing more suitable to the conditions [**21,** 30, 26] ;

(*c*) The accurate determination of the relation between the number of warp breakages (for different qualities of yarn and sizing) and different degrees of temperature and humidity.*

2. *Lighting.* (*Cotton, Linen and Silk Weaving.*)—During periods of artificial light, production in silk-weaving has been shown to fall by about 10 per cent. as compared with daylight, even when the system of lighting is one which is at present regarded as satisfactory. A precisely similar effect has been independently observed in fine linen weaving, where production fell 11 per cent. in similar circumstances. In the coarser process of cotton-weaving the same effect is sometimes (though not always) present, amounting in one instance to 5 per cent. reduction [**9,** 33 ; **20,** 18 ; **23,** 21].

It is suggested that experiments should be initiated to discover the illumination and general lighting arrangements which would eliminate this result.

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* Third Annual Report of the Board, p. 44.

3. *Distribution of the Hours of Work.*—The most suitable distribution of the hours of work is an important subject for investigation. Existing information indicates that a one-break day, is, on the whole, preferable to a two-break day, but experience suggests that the actual spells of work under the former system may be too long and owing to the low efficiency in the pre-breakfast spell that rest-pauses within the spells may be beneficial. Further investigation on this subject appears to be desirable [**23,** 10].

(*b*) Working Methods.

1. *Training.*—In silk weaving large and consistent differences were found in the rates of performing standard operations and in the methods adopted by the weavers [**17,** 22]. Also, the weavers whose methods were not good had a greater amount of work to do per unit of output than those who adopted good methods [**17,** 28]. Similar though smaller differences were found to exist amongst cotton weavers [**23,** 28].

In both cases these differences were probably due in part to imperfect training and to the present system under which it is largely a matter of chance whether any given learner is attached to a good teacher. The suggestion is made that the present system should be replaced by the installation of properly equipped and staffed training schools or institutions [**17,** 38; **23,** 52]. The subject is discussed at some length in Part II of the Fourth Annual Report of the Board (p. 41).

2. *Design of Machinery.*—Where, as in most textile processes, work consists of the repetition of similar movements throughout the day, the design of the machine or of its parts in relation to the operative is a matter to be taken into account in considering maximum comfort and efficiency. Suggestions are made as to how the design of ordinary looms fail in this respect [**20,** 6], and two types of bobbin winding frames are compared in regard to the amount of stooping and reaching demanded of the operatives [**8,** 10].

3. *Physical Factors in Efficiency.*—In weaving, an optimum relation exists between loom speed and efficiency for different classes of cloth, since an increase in speed beyond a certain point results in an increased number of breakages ; the speed aimed at therefore is the one which will give the highest output compatible with good quality of cloth and the ability of the weaver to attend to the breakages. Once the most suitable speed has been determined, it is clearly desirable that this should be maintained, yet variations in loom speed, apparently unnecessary, seem frequently to occur with the result that an avoidable reduction in efficiency follows [**23,** 46].

(*c*) Administrative and Miscellaneous.

1. *Sickness and Mortality.*—The general and ultimate effect of the conditions of work upon cotton operatives can be ascertained only by the collection of sickness and mortality statistics. This procedure is necessary for the determination of the effects of special conditions, such as the humidification of weaving sheds, the existence of card-room dust, etc., upon the health of the operatives [**23,** 50.]

2. *Records.*—The almost universal absence of record-keeping in the textile industries has been frequently the subject for comment; it appears in fact that the only records ordinarily kept are those which are necessary for assessing the wages due to each operative.

Two kinds of records which would eventually become of great service are mentioned. The first of these is the so-called efficiency book, in which would be entered the performance of each loom expressed as a percentage of the performance of ideal non-stop loom engaged on the same class of cloth. The wide uses (including the more accurate assessment of piece rates) to which data of this kind when collected in sufficient quantity could be put, are discussed [**9,** 11; **23,** 50].

Similarly, a systematic recording of time lost on the part of the workers, with the causes, would go far to indicate the conditions capable of improvement. Record keeping in itself, when confined to the limits of one factory, suffers from the defect that it only enables a comparison to be made between different departments and smaller units. By extension of this practice to the whole of the industry, and by collecting and analysing the returns by some central authority, a "norm" could be established for the industry itself and the information available to individual employers would be much wider in scope, for the whole factory would now be in the position occupied by the department in the former system, and every employer would know at once how far the health, etc., of his own workers exceeded or fell below the average, and if the latter, could endeavour to trace the cause. Some of the questions to which under this system definite answers could be given are stated in the Report [**9,** 17].

2. *Booking-up or Making-up Day.* (*Cotton and Silk Weaving.*)—The day and time on which the weekly booking-up takes place has some relation to productive efficiency, and the best arrangement for this is discussed in two Reports [**9,** 56; **23,** 32].

3. *Type of Work.*—Up to the present investigations in the cotton industry have been confined to the manufacture of plain cloth. It is suggested that the relative efficiency and variations in working capacity in the weaving of fancy fabrics should also be determined [**23,** 50].

REPORTS.

No. 7.—Individual Differences in Output in the Cotton Industry, by S. Wyatt, M.Sc., M.Ed. *Price 6d. net.*

No. 8.—Some Observations on Bobbin Winding, by S. Wyatt, M.Sc., and H. C. Weston. *Price 1s. 6d. net.*

No. 9.—A Study of Output in Silk Weaving during the Winter Months, by P. M. Elton, M.Sc. *Price 2s. 6d. net.*

No. 17.—An Analysis of the Individual Differences in the Output of Silk-Weavers, by P. M. Elton, M.Sc. *Price 1s. 6d. net.*

No. 20.—A Study of Efficiency in Fine Linen Weaving, by H. C. Weston, M.J. Inst. E. *Price 1s. 6d. net.*

No. 21.—Atmospheric Conditions in Cotton Weaving, by S. Wyatt, M.Sc. *Price 2s. net.*

No. 23.—Variations in Efficiency in Cotton Weaving, by S. Wyatt, M.Sc. *Price 3s. net.*

II.—METAL INDUSTRIES.

A.—IRON AND STEEL TRADES.

(*a*) Working Conditions.

1. *Hours of Work.*—The effects of hours of work, length of shift, etc., are indicated for tinplate manufacture (millmen's work), charging of blast-furnaces, steel-making by the open hearth process, and rolling-mill processes [**1,** 6 ; **5,** 20, 38, 63 ; **6,** 8]. In fixing standard hours of work many issues have of course to be taken into account, but the relation of hours to efficiency and fatigue is clearly one factor to be closely considered. Within the limits observed, the effect of reducing hours is generally to bring about an increase in hourly output, though this increase is usually insufficient to compensate for the shorter hours, so that the total output per shift is less on the shorter than the longer hours. It may take from 2 to 13 months after the reduction of hours before the increasing output attains a steady level [**6,** 4, 11, 23].

One particular matter, to which special attention is drawn, is the long 16-hour shift worked by blast furnacemen every third week, which must induce a state of over fatigue and cause loss of efficiency. At present one shift usually works from 6 a.m. to 10 p.m. on Sunday, and a second shift from 10 p.m. to 6 a.m. (Monday). It would probably be very much better if the two shifts worked for 12 hours each, e.g., from 6 a.m. (Sunday) to 6 p.m. and from 6 p.m. to 6 a.m. (Monday) [**5,** 18].

2. *Temperature.*—Seasonal variations in output are found to be very marked in work involving exposure to high temperatures, especially where it depends largely upon muscular effort. In tinplate rolling, comparing extreme conditions, the output of the shift during the hottest weather is estimated to be about 30 per cent. less than in the coldest weather. It is shown that much of this difference can be eliminated by suitable ventilation, as is shown by the evenness of output in well-ventilated shops [**1,** 22].

Similar but smaller variations were observed in blast furnace charging, open hearth steel melting, puddling, and at the rolling mills [**5,** 17, 39, 56, 66].

3. *Effects on Health.*—The sickness data tabulated show that the men engaged on hot and heavy work suffer an excessive amount of sickness from rheumatism and respiratory diseases. This is especially true of the puddlers. It seems probable that this is due to the men sitting about in draughts when their clothes are wet from perspiration. It is desirable to determine how far this is a fact, and also to know to what extent the puddlers, steel melters and others are in the habit of changing their clothes when they are wet through as the result of excessive perspiration incurred during working hours [**5,** 81].

The provision of some shelter for the men at present unprotected from the weather, and of rooms in which clothes could be changed is advocated [**5,** 96].

(*b*) Working Methods.

Several suggestions are made as to alleviation of the more arduous forms of work.

1. *Charging of Blast Furnaces.*—The work of the barrow-men on hand-charged furnaces, which is very laborious, can be lightened in several ways. It was found [**5,** 10] that at different works the weight of iron ore with which the barrows were charged varied from 10½ to 16 cwt. ; that of limestone varied from 5 to 15 cwt., and that of coke from 6 to 10 cwt. There is, therefore, considerable variation in practice in the loads conveyed, though it is apparent that for an average man there must be some one weight which is the least fatiguing. This can only be determined by further experiment, since the empty barrows weigh about 5 cwt., and accordingly the lighter the load the greater is the total work done in transporting a given weight of material to the furnace hoist.

Again, the weight of iron ore loaded into the barrows is usually about twice as heavy as the weight of limestone [**5,** 10]. Yet it is the custom to keep one set of men continuously on ore loading and another on limestone loading throughout the shift. The men sometimes change over once a week, but it would probably be better if they were allowed to change over in the middle of each shift. Since the men often set their barrows to the most convenient height, it might be necessary to arrange that the pairs of men who changed over were roughly of the same stature.

2. *Open-hearth Steel Furnaces.*—It is pointed out that every effort should be made to reduce the time for fettling to a minimum, for there is evidence that the strain imposed by it on the men shortens their average duration of life by several years [**5,** 27, 91]. The average fettling time was found to vary from 27 to 203 minutes at various works, and even at the works in the same district, where the furnaces were used for making basic steel from molten iron of similar composition, it varied from 63 to 203 minutes [**5,** 25]. Statistical information similar to that recorded in the Report (Table IV) could be collected at a large number of steel works with very little trouble, and it would probably throw a good deal of light on the causes of variation in fettling time, e.g., the dependence of this time on the structure and age of the furnaces. Subsequently, a series of experiments would have to be made in order to determine the relationship of fettling time to the composition of the furnace lining, the iron and iron ores added, the steel produced, and other conditions of production. It is pointed out that fettling is to a very large extent avoided in the modern Talbot tilting furnaces [**5,** 38].

3. *Rolling Mills.*—The fatigue of the work of the steel melters can be greatly diminished, and the efficiency in the running of the rolling mills can be increased by reducing the intermittency with which the furnaces are tapped. In certain works, some reduction is already effected by charging half the furnaces on Saturday morning and the other half on Sunday night, but a more marked result would probably be obtained if it could be arranged that the men start work at different times on Sunday [**5,** 47, 58].

The Report points out that rolling mill delays are due partly to lack of steam pressure. It is desirable to investigate the causes of low pressure, and by taking hourly records of low pressure to find out how far it is dependent on fatigue in the men, with a consequent reduction in the efficiency of stoking, or on other factors [**5,** 72].

4. *Iron Founding.*—The methods adopted in an iron foundry with the full concurrence of the workers, the introduction of which greatly increased output, are described [**3**].

(*c*) Administrative.

1. *Records.*—Two kinds of records which would yield valuable information have been suggested :—

(i) Output should be tabulated and compared month by month. Any substantial reduction during the summer months, as compared with the winter months, will indicate that the conditions of production induce undue fatigue in the men in hot weather. It will probably often be found that the shops and sheds are too much shut in and that ventilation is inadequate. Hence, systematic observations ought to be made on the atmospheric conditions (temperature and air currents) of the shops in various works, both good and bad.

(ii) Lost time records should be kept regularly, and the amount of time (*a*) unavoidably lost from sickness, and (*b*) avoidably lost, separately distinguished. If the men were grouped according to their occupation, and the lost time of each group calculated separately, valuable information might be obtained as to the causes of lost time, and the means of avoiding it.

REPORTS.

B.—METAL POLISHING.

The investigation is directly concerned only with the polishing of spoons and forks, but the results are applicable with little modification to all processes of grinding or polishing by means of a revolving wheel.

(*a*) Working Conditions.

1. *Vibration.*—It is suggested that investigation should be made on the effects of vibration on the operatives. An attempt was made to deal with this problem in the course of the investigation, but no conclusions were reached [**15,** 57].

2. *Seats.*—The provision of seats for optional use by the operatives resulted in a slightly increased output and was appreciated by all the workers [**15,** 10].

(*b*) Working Methods.

1. *Training.*—In the processes studied astonishing differences were found both in the methods of work and in the movements adopted by workers with long years of experience. Eventually a set of systematised movements was formulated and employed in a training scheme, which had the result of greatly improving output and increasing earnings. Novices trained on this system were able after two weeks to reach a standard of efficiency said hitherto to be attainable only after months of practice [**15,** 17, 37].

The opinion is expressed that a definite course of training should be given to all workers who enter the metal polishing trades, instead of allowing them to learn their tasks as best they can. The present method is stated to be wasteful of human energy and is to the advantage of neither employer nor operative [**15,** 57].

2. *Abrasives.*—Various comments are made on the proper use of abrasives, and it is suggested that effort should be made to devise an abrasive which is less dusty and dirty than sand. If this were done, the "roughers" would be saved much discomfort [**15,** 57].

3. *Speed, etc., of Revolution.*—Further investigation is desirable on the most economical speed of revolution of the wheels, and their optimum size and breadth [**15,** 55].

REPORT.

No. 15.—Motion Study in Metal Polishing, by E. Farmer, M.A. *Price* 2*s. net.*

III.—BOOT AND SHOE INDUSTRY.

(*a*) Working Conditions.

1. *Distribution of Weekly Output.*—Records obtained from five factories showed a consistently low rate of output on Saturday as compared with the other days of the week. The actual output on Saturday, when doubled to allow of comparison with other week-days, was often less than 75 per cent. than the daily average for the rest of the week. In cases where Saturday work had been abandoned, the output on Friday did not fall to the same extent [**10,** 17].

2. *Temperature and Ventilation.*—The conditions in a large number of factories were explored by means of the kata-thermometer and were found to compare favourably with other industries investigated. The more important conclusions are as follows :—

(*a*) Existing systems of ventilation which are adequate in winter do not always ensure desirable physiological conditions in summer. In such instances the use of portable electrical fans is advocated [**11,** 21, 24].

(*b*) The adequate ventilation of gold-stamping and other rooms shut off from main air currents is often difficult. Suggestions are offered as to how this can be secured [**11,** 21, 27].

(*c*) The "kata cooling powers" and temperatures are not always adapted to the nature of occupations, e.g. :

(i) There is some indication that clicking rooms were too cold in winter and too hot in summer.

(ii) In press rooms in summer the "cooling powers" were below the standards recommended.

(iii) In lasting and finishing rooms, where heavy manual work was in progress, "cooling powers" and temperatures for both summer and winter were unsatisfactory compared with recommended standards.

(iv) Shoe rooms were found to be too cold in winter, and in summer these departments, where sedentary work was carried on, were found to have higher "cooling powers" than those experienced in the heavy manual work of lasting and finishing [**11,** 55–57].

(*d*) Air velocities in each department were found to be greater in summer than in winter. This may be due to the opening of windows in the former season. The question of making better use of outdoor air velocities in winter, and at the same time avoiding draughts, is one of importance.

(*b*) Working Methods.

1. *Team Work with Rest Pauses.*—In the press-room in one factory, a system was introduced on an experimental basis under which double presses were worked with a team of three girls, each operative working 40 minutes in each hour and resting 20 minutes, instead of the usual method of employing two girls continuously throughout the day. An increase in output immediately resulted, ranging from 34 to 75 per cent. and averaging 44 per cent. over the six presses concerned. The experiment involved, of course, the employment of 50 per cent. additional workers, but it is of interest, not only in illustrating the effects of rest-pauses but also practically in indicating a method whereby output can be increased without incurring the expense of purchasing new machines [**10,** 28].

2. *Individual Differences.*—Examination of the output records of individual workers at several operations showed that good workers with high output consistently produce at an even pace, whilst the poorer workers tend to spurt irregularly. This point is important in measuring the efficiency of methods of training and in determining the optimum length of the shift and the need for rest pauses [**10,** 18].

REPORTS.

No. 10.—Preliminary Notes on the Boot and Shoe Industry, by J. Loveday, B.A., and S. H. Munro. *Price* 1*s.* 6*d. net.*

No. 11.—Preliminary Notes on Atmospheric Conditions in Boot and Shoe Factories, by W. D. Hambly, B.Sc., and T. Bedford. *Price* 3*s. net.*

IV.—POTTERY INDUSTRY.

The investigation undertaken by the Board, with the co-operation of the National Council for the Pottery Industry, was mainly confined to the conditions in potters' shops. The chief points emerging from the inquiry are as follows :—

(*a*) Working Conditions.

1. *Temperature.*—The temperature in potters' shops, especially those with leaf and dobbin stoves, appear to be considerably higher than those prevalent in other industries, where the operatives are engaged in active work comparable with that of the potters. These conditions are to some extent due to the action of the potters themselves, who seem to prefer a high temperature, and keep windows shut until the temperature reaches 67° to 70° [**18,** 11].

Notwithstanding the high temperature, the velocity of the air currents in potters' shops, as estimated by kata-thermometer, is very low. It averaged only 17 ft. per minute in winter and 21 ft. in summer, whilst in boot and shoe factories the corresponding values were 35 ft. and 37 ft., or nearly twice as much.

High temperatures are not only uneconomical, as implying an unnecessary waste of heat, but there is reason for thinking that they are bad for the health of the workers [**18,** 26].

These conditions could be greatly improved by the elimination of back draught from the potters' stoves, thus preventing the escape of heat into the air of the room, and provisional recommendations on this point are given for each type of stove examined [**18,** 69].

It is pointed out, however, that before this question can be finally settled the respective parts played by temperature and ventilation in the drying of ware should be established. The proposal is made that experiments on this subject should be carried out by the industry,* in continuation of the preliminary observations already described [**18,** 56].

(*b*) Working Methods.

2. *Movement Study.*—Though this question was only studied superficially, there appears to be a wide scope for movement study in various pottery processes. Not only is the proportion of manual occupations in the industry unusually high, but the

* Third Annual Report, p. 66.

wide individual differences in output observed amongst plate makers, saucer makers and towers appeared to be due largely to the diverse methods adopted.*

3. *Labour-saving Devices.*—Compared with other industries, the pottery industry seems to have been backward in adopting labour-saving devices. Though there may be special reasons for this policy, such as the exceptional fragility of the ware at certain stages, many processes seem to call for consideration in this respect. Specific suggestions on this point are made.*

REPORT.

No. 18.—Two Investigations in Potters' Shops, by H. M. Vernon, M.D. and T. Bedford. *Price* 2*s.* 6*d. net.*

V.—GLASS INDUSTRY.†

(*a*) Working Conditions.

1. *Temperature.*—There is a distinct seasonal variation in production, output being higher in winter than in summer. This falling off of output during the hotter months might be eliminated or reduced by better ventilation in the neighbourhood of the workers exposed to heat. Further investigation on this point is suggested [**24,** 8].

2. *Hours of Work.*—The relative hourly efficiency in bottle-blowing (both by hand and on semi-automatic machines) appears to have been increased by shortening the shift from 10 hours to 8 hours, though this increase is not in itself sufficient to bring the output of the shorter shift up to that of the longer. In a continuous process of this kind, however, hourly output rather than shift output is the important factor in regard to production. Here the advantage is clearly with the shorter shift, and in this instance becomes still more pronounced since on the longer shift work was carried on during only 20 out of the 24 hours [**24,** 4, 5].

Some information is given as to the comparative efficiency of the shifts. On the three-shift system the night shift is always more efficient than the morning shift and not much less efficient than the afternoon shift. Under the system, however, in which 12 of the 24 hours are spent in alternate 6-hour shifts, the night shifts are consistently less efficient than the day shifts [**24,** 10].

(*b*) Working Methods.

3. *Change of Activity.*—It is suggested that fatigue might be reduced and efficiency increased by alternating the work of a "chair" or gang, instead of the present system of allowing the same work to be done throughout the whole shift by each member of the group [**24,** 17].

REPORT.

No. 24.—A Comparison of different Shift Systems in the Glass Trade, by E. Farmer, M.A., R. C. Brooks, M.A., and E. G. Chambers, B.A. *Price* 1*s.* 6*d. net.*

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* Third Annual Report, p. 66.

† The investigation into the glass industry was undertaken by the Board and the Glass Research Association jointly.

VI.—LAUNDRY INDUSTRY.

(*a*) Working Conditions.

1. *Temperature and Ventilation.*—The atmospheric conditions in laundries seem to compare very unfavourably with certain other industries, and much room for improvement exists. The cooling-power of the air, as estimated by the kata-thermometer, is generally low, especially in the neighbourhood of calenders and presses. It is suggested that the industry should consider how the temperature can be kept down, e.g., by lagging of pipes, or the air movement increased by the installation of fans [**22,** 45].

2. *Hours of Work.*—There is evidence that fatigue, as might be expected, is greater at the end of the 10-hour day than at the end of the 9-hour day. Any further prolongation of the working day would probably result either in diminished output or in undue strain, which would ultimately have effects the next day as well [**22,** 6, 14, 53].

3. *Rest Pauses.*—There is some evidence that short pauses of 10 to 15 minutes introduced in the middle of the long 5-hour spell are beneficial to the worker and tend to increase output [**22,** 19].

4. *Change of Activity.*—Where a process involves frequent repetition, with demands on one set of muscles, e.g., in sorting goods from the floor, much benefit would probably follow a change over to work which brings other muscles into action [**22,** 49].

5. *Seats.*—The provision of suitable seats for workers, so as to allow them to adopt an occasional change of posture is advocated [**22,** 49].

6. *Shoes.*—The most suitable shoe for long standing is discussed, and further investigation on this point suggested [**22,** 50].

(*b*) Working Methods.

7. *Organisation.*—The organisation at the average laundry usually leaves much to be desired, and entails much unproductive time. Particular suggestions on this point are offered [**22,** 47].

8. *Supervision.*—The type of forewoman and manageress was found to have a marked influence on the smooth running of the laundry [**22,** 48].

9. *Design of Machines.*—Many machines in the laundry industry seem to be ill-designed from the point of view of ease of working. Simple alterations in this respect often make a marked difference [**22,** 51].

REPORT.

No. 22.—Some Studies in the Laundry Trade, by May Smith, M.A. *Price* 2*s.* 6*d. net.*

VII.—REPETITION WORK.

(*a*) Working Conditions.

1. *Rest Pauses.*—The practice of breaking up long spells of work by the introduction of short rest periods has already been adopted in some industrial establishments and has been applied and studied in some well-known experiments. In these, however, the introduction of the rest-pauses was usually accompanied by other important changes in the conditions of work, so that the influence of the rest-pauses alone cannot be estimated.

Some recent work on the subject suggests that in light repetitive work the judicious introduction of a short rest-pause of 10 to 15 minutes into a spell of $4\frac{1}{2}$ to 5 hours will be eventually followed by a small but genuine increase in output, notwithstanding the shorter time worked, though this effect is often not fully apparent until some months after the change has been made. The increase is usually of the order of 5 to 10 per cent.

Further investigation, however, on the nature and on the best duration and position of the rest pause is still required [25].

2. *Change of Activity.*—In certain packing processes a comparison between continuous repetitive work and work of which the character was slightly changed at intervals suggests that although the highest output occurs on days on which the same type of repetitive work is continued throughout, no diminution need necessarily result from changing the type of work every half-hour, a system which was much preferred by the operatives. More frequent changes however, caused a lower output and greatly increased the amount of unproductive time. These results suggest that even a slight change in occupation may be equal or even superior to actual rest-pauses, and practical experiment on the subject is suggested [**26**].

3. *Change of Posture.*—Where the main occupation consists of the continuous repetition of the same operation, beneficial results will probably often follow an occasional slight change in posture from standing to sitting or *vice versa* [**26**, 8].

(*b*) Working Methods.

1. *Training.*—In certain repetitive processes (sweet dipping and chocolate covering by hand) a largely increased output (together with a quicker attainment of proficiency) was obtained by the adoption of systematic method of training, based on movement study [**14,** 36, 43].

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No. 14.—Time and Motion Study, by E. Farmer, M.A. *Price* 2*s. net.*

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